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GENERAL SPECIFICATIONS

— FOR —

CONCRETE BRIDGES

— BY —

WILBUR J. WATSON
Consulting Engineer

1908

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of the
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PREFACE.

The Author believes that these specifications will meet an actual need of the profession, and that no further apology is necessary for their publication.

While most of the clauses represent ideas gained from personal experience, many of them have been obtained from published articles in the engineering press, from suggestions made by other Engineers, etc., and the writer wishes to especially acknowledge his indebtedness to the valuable experiments conducted by Prof. Arthur N. Talbot at the University of Illinois.

The Author believes that these specifications will be found especially useful in cases where they are made the basis of competitive designs, as in that case it will be possible to compare all such designs on an equal basis.

In using these specifications, it should always be borne in mind that many clauses, and especially those giving instructions for designing and proportioning, must be modified to suit different conditions, and different materials than those assumed.

The Author cordially invites criticism of these specifications.

WILBUR J. WATSON.

January, 1908.

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General Specifications
for
Concrete Bridges.

I.—CLASSIFICATION.

1. **Concrete Bridges** will be divided according to use into the following classes:

Class A.—Heavy Railroad Bridges.
Class B.—Light Railroad Bridges.
Class C.—Heavy Electric Railway Bridges.
Class D.—Light Electric Railway Bridges.
Class E.—City Highway Bridges carrying Electric Railway tracks.
Class F.—City Bridges without Electric Railway tracks.
Class G.—Suburban Bridges carrying Electric Railway tracks.
Class H.—Suburban Bridges without Electric Railway tracks.
Class I.—Light Country Bridges.
Class J.—Foot Bridges.

2. **Concrete Bridges** will also be divided according to design into the following types:

Type 1.—**Beam** Bridges, including slabs, beams, girders, columns, etc.
Type 2.—**Truss** Bridges.
Type 3.—**Arch** Bridges under 40 ft. span — Culverts.
Type 4.—**Arch** Bridges 40 ft. span and over.

3. **Bridges** will be **designated** by reference to class and type; thus a city highway arch of 60 ft. span and carrying Electric Railway tracks, will be designated as Class E-4.

II.—LOADS.

4. **Class A Bridges** will be designed, unless otherwise specified, for Coopers E 60 loading (See Appendix D) and will be used for all railroads carrying heavy traffic, hauled by locomotive power.

5. **Class B Bridges** will be designed, unless otherwise specified, for Coopers E 40 loading (See Appendix D) and will be used for railroads carrying light traffic, hauled by locomotive power.

6. **Class C Bridges** will be designed, unless otherwise specified, for two 100 ton (200,000 lbs.) cars entrain, wheel base 6 feet, 22 feet c to c of trucks, (See Appendix D) and will be used for Electric Railways carrying very heavy traffic.

7. **Class D Bridges** will be designed, unless otherwise specified, for two 50 ton (100,000 lbs) cars entrain, wheel base 6 feet, 22 feet c to c trucks, (See Appendix D) and will be used for Electric Railway bridges carrying light traffic.

8. **Class E Bridges** will be designed for (a) a concentrated live load of twenty-four tons (48,000 lbs) on two axles, ten (10) foot centers and five (5) foot gauge, assumed to occupy a width of (10) feet; and (b) a uniformly distributed load of one hundred and twenty-five (125) lbs. per square foot on all roadways and footwalks. The Street Railway tracks will be assumed to carry the loads specified for Class D Bridges.

9. **Class F Bridges** will be designed to carry the concentrated and uniformly distributed live loads as given for Class E.

10. **Class G Bridges** will be designed to carry a concentrated live load of twenty-four (24) tons and a uniformly distributed live load of one hundred (100) lbs. per square foot of roadways and footwalks arranged as for Class E Bridges. The Street Railway tracks will be assumed to carry the loads specified for Class D Bridges.

11. **Class H Bridges** will be designed to carry a concentrated live load of eighteen tons (36,000 lbs.) and a uniformly distributed live load of one hundred (100) lbs. per square foot arranged as for Class E.

12. **Class I Bridges** will be designed to carry a concentrated live load of twelve tons (24,000 lbs.) and a uniformly distributed live load of seventy-five (75) lbs. per square foot arranged as for Class E.

13. **Class J Bridges** will be designed for a uniformly distributed live load of seventy-five (75) lbs. per square foot.

14. An addition will be made to all stresses caused by concentrated live loads to cover the effects of **impact,** vibration, etc., which will be determined in the following manner:

For Classes A and B; Impact $= S\frac{300}{L+300}$, and for Classes C and D; $I = S\frac{200}{L+300}$.

For all other Classes $I = S\frac{150}{L+300}$.

where I = impact to be added to the liveload stress.

S = calculated maximum live load static stress.

L = length of loaded distance in feet which produces the maximum stress in the member.

See Appendix E.

The sign + will be used to indicate compressive, and the sign —, tensile stresses.

15. When the live load stress is of an opposite sign to the dead load stress, then the impact shall be assumed to be in all such cases equal to the live load stress, and in case of reversal of stress by live load the

member shall be proportioned for a stress equal to the sum of the greater and one-half the lesser maximum stresses.

16. **Wind Pressure** shall be assumed at 50 lbs. per sq. ft. on the exposed surface of the unloaded structure, or 30 lbs. on the loaded structure in combination with a moving wind load of 300 lbs. per lineal foot on the loaded chord.

17. When the structure is on a curve the **Centrifugal Force** must be considered and calculated, for all classes carrying tracks, by the formula.

$C = 0.03\ W\ D$ for curvature up to 5°.

Where C = Centrifugal force in lbs.
D = degree of curvature.
W = weight of train.

The co-efficient for centrifugal force (0.03) shall be reduced 0.001 for every degree of curvature above 5°

18. The effect of suddenly **stopping** the moving loads must be considered; the co-efficient of friction of wheels sliding upon the rails being assumed at 0.2.

III.—ASSUMPTIONS FOR COMPUTING AND DESIGNING.

19. The weight of **Reinforced Concrete** shall be assumed to be, per cubic foot, for stone or gravel concrete, 156 lbs.; for average slag concrete, 132 lbs.; unless the precise weight of the material to be used be determined by weighing.

20. The weight of **Tracks** shall be taken at 250 lbs. per lineal foot for ballasted construction, and 400 lbs. per lineal foot for timber deck construction.

21. The weight of **Ballast** for classes A, B, C and D shall be assumed at 1200 lbs. per lineal foot of track with subgrade 21 inches below top of rail and 14 ft. wide for single track and 27 ft. wide for double track.

22. The weight of **Earth Fill** shall be assumed at 100 lbs. per cubic foot.

23. The weight of **Timber** shall be assumed at 4 lbs. per foot B. M. if untreated or 5 lbs. if creosoted.

24. The weight of **Brick or Stone Paving** shall be assumed at 150 lbs. per cubic foot; of **Asphalt** 136 lbs. per cubic foot.

25. The weight of **Sand Filler** shall be assumed at 120 lbs. per cubic foot.

26. The **Concentrated Loads** for locomotive and motor wheels may be considered as **distributed** over five (5) feet of track, but the concentrated loads specified for roadways must be considered as carried at a single point.

27. The load on railroad or electric railway tracks shall be considered as distributed over a width equal to the length of tie used, except when a fill of over 8 feet is used, when the load may be considered as distributed over a width equal to the spacing of the tracks, or in the case of single track, the angle of distribution of pressure may be taken at 30° with the vertical at the ends of the ties.

28. The **Length of Span** for beams, girders and trusses shall be considered to be the distance between the centers of supports.

29. The **Length of Span** for arches shall be considered to be equal to the span of the neutral axis of the arch ring, measured from the point where it intersects the vertical to the tangent to the curve at the spring point of the intrados.

30. The **Rise** of the arch shall be assumed to be the distance from the line connecting the ends of the neutral axis, as determined under article 29, to the neutral axis at the crown.

31. All slabs, beams and girders of monolithic construction shall be considered, unless otherwise shown on the drawings, to be **Partially Continuous** and shall have an amount of reinforcing in the upper part of the beam at the supports equal to at least one-

half that in the lower part of beam at the section of maximum positive moment. (See Art. 48.)

32. At the end supports of continuous beams, girders, and slabs, the reinforcement for the negative bending moment need not exceed 25 per cent of the reinforcement required at the section of maximum positive moment.

33. The bending moment due to external forces shall be determined by the usual methods for simple beams; and for partially continuous beams the maximum positive bending moment shall be taken at 8-10 the corresponding moment as determined for simple beams, and the maximum negative moment at intermediate supports shall be taken at one-half the maximum positive moment, and at end supports it shall be taken at one-fourth the maximum positive moment.

34. The reactions for partially continuous beams shall be taken at 1-1/4 times the reactions for simple beams at all intermediate supports and as equal to the reaction for simple beams at end supports, and in calculating shearing stresses, and providing reinforcing members to resist same, this increase shall be taken fully into account.

35. In the case of **Square Slabs** reinforced equally in both directions, the bending moment in each direction shall be taken at one-half that for slabs reinforced in one direction only.

36. In the case of **Rectangular Slabs** having one side longer than the other, but not exceeding one and one-half times the length of the other side, the loads may be considered as carried to each side if the reinforcing be designed to properly distribute the loads to the four sides.

37. When loads are considered as carried to four sides of a square or rectangular slab as above, the bending moment on the supporting beams must be increased 33-1/3 per cent over that for simple beams owing to

the concentration of the loads near the center of the beams; and in the case of rectangular slabs, the unequal distribution of the panel loads between the beams must be considered.

38. Allowance must be made in proportioning intermediate columns for the **Contraflexure** caused in the case of monolithic construction by the full live load occupying one panel and no live load in the adjacent panels, and the moment over the supports will be assumed to be divided between the girder or other member carrying such load to the column, and the column, in proportion to the squares of their respective effective depths. By the effective depth of the column is meant the effective depth considering the column to act as a beam to resist flexure. (See Appendix B.)

39. In addition to the requirements of Art. 38 the effect of **Eccentric Loading** must be fully taken into account.

40. All tensile stresses will be considered to be resisted entirely by the steel reinforcing, no allowance will be made for concrete in tension.

41. The **Stress-Strain Curve** of concrete in compresion will be assumed to be a straight line.

42. The ratio of the **Modulus of Elasticity** of steel to that of concrete shall be taken as equal to 15 for stone and gravel and slag concrete and 30 for cinder concrete and to be constant with the limits of the allowable range of stress.

43. A plane before bending shall be assumed to remain a plane after bending.

44. Initial stresses shall be neglected.

45. In the computation of the resistance of T beams the portion of the slab that may be assumed to assist in compression shall be dependent upon the horizontal shearing stresses and in no case shall the slab portion exceed in total width 12 times the thick-

ness of the slab nor 6 times the thickness of the stem, nor 1/4 the span of the slab.

46. When the thickness of the slab portion or flange of T beam is equal to or greater than .35 the depth of the T beam, the moment of resistance, etc., shall be determined in the same manner as for a rectangular beam. See Appendix B.

47. When the thickness of the slab portion is less than .35 the total depth of the beam, the increased compression in the slab must be taken into account. See Appendix B.

48. In designing partially continuous T beams the compression in the lower portion of the stem at point of maximum negative moment must be computed and if it exceeds the maximum allowable unit stress on concrete sufficient reinforcement must be provided to take up the excess stress.

49. The concrete must be able to transmit the entire shear from a beam into its connections without any reliance upon the shearing resistance of the steel bars unless the reinforcing be of such a character that it will transmit the shear in itself without reliance on the surrounding concrete, in which case it may be considered to carry the entire amount of shear which it would be capable of carrying were it not encased in concrete.

50. Whenever the unit shearing stresses on concrete exceed the allowable unit shearing stresses as given herein, steel stirrups must be used to provide for the excess shear and be proportioned to resist the tensile component of the excess web stresses, or part of the rods must be bent up in such a manner as to provide necessary resistance, but in the latter case care must be taken to leave enough rods in the lower portion of the beam at the ends to provide the required adhesion. Stirrups will be preferred to bending up the rods.

51. When conditions are such that a plane of horizontal cleavage is likely to exist in a beam or girder, then enough stirrups must be provided to take care of all shearing stresses without any reliance on the concrete to resist shearing along such plane. Unless it is certain that the lower portion of T beams will always be laid at the same time as the upper portion or slabs, T beams must always be assumed to have such a plane of cleavage at the juncture of the beam proper with the slab.

52. All reinforcing bars must be of sufficient length to develop the full stress in the bar at all points without exceeding the allowed unit stress of adhesion of concrete to steel. (See Art. 70) or proper anchorage must be provided.

53. In computing reinforced concrete **Footings,** the maximum compression at the top of the footing due to the direct load from the columns combined with the compressive stress due to bending in the footing shall not exceed the allowable limits for concrete in compression due to bending. The footings must be deep enough to transmit the entire load from the columns through shear on the concrete without reliance upon the steel reinforcing of the footing for assistance in such resistance to shear. In reinforcing footings the reinforcing bars must be so spaced as to properly transmit the load carried by the column uniformly into the foundation. All reinforcing bars in footings must be protected by at least four inches of concrete.

54. In all cases where **Combined Stresses** occur, such as the bearing of heavy concentrated loads on the top of beams, combined with the compression in the beam due to bending, etc., the resultant combined stress must not exceed the maximum allowed unit stress.

55. In the case of the so-called **Mushroom System** of construction or other systems which are not subject to rigid stress analysis, the designs will be accepted

only subject to tests upon the completed structure as hereinafter provided for.

56. In the design of reinforced concrete **Retaining Walls**, the lateral pressure due to backfilling shall be assumed to act at one-third the height of the wall and to be equal in amount to the weight of the material included by a plane bisecting the angle of the plane of repose of the material measured from the vertical at the wall and the upper surface of the back filling material. (See Apendix F.)

57. In case any super-imposed load is included between the point where this bisecting plane cuts the surface of the ground and the back of the retaining wall, such load shall be assumed to exert a uniform horizontal pressure per sq. ft. against the back of the wall, equal to the vertical unit pressure on the back fill, multiplied by the tangent of the angle of repose of the back fill. The retaining walls will be reinforced sufficiently to resist all moments and shears due to this lateral thrust in combination with such other external forces as may come upon them. They must also be able to resist sliding and overturning due to the combination of these external forces.

58. Whenever the material back of a retaining wall is liable to be saturated with water, the wall must be designed to resist the full theoretical hydraulic pressure.

59. All **Arches** must be carefully analyzed preferably by methods of analysis based upon the elastic theory of the arch, and at least two conditions of live load must be assumed, the live load covering the entire arch and covering one-half the arch. The method developed by Prof. Cain is recommended, (Van Nostrand Science Series.)

60. All arch rings must be of sufficient thickness so that the resultant line of pressure as found by the methods prescribed in Article 59 will not pass outside

of the middle third of the arch ring, or else they must be reinforced.

61. A **Range of Temperature** equal to ± 30° Fahr. will be assumed, and stresses due to temperature will be combined with dead and live load stresses to obtain maximum unit stresses.

62. The **Amount of Reinforcing** may be varied at different sections to meet the requirements of the bending moments, but must never be less than 1/300 of the concrete area, for either extrados or intrados, at any section of the arch ring where tension may occur, due to dead load, live load, or temperature changes.

63. The pressure of **Earth Fill over Culverts** shall be assumed to be equal to the weight of material included between two planes at the ends of the span, making an angle with the vertical equal to one-half the angle of repose of the material with the vertical.

In case these planes intersect above the top of the fill, they shall be considered to be vertical planes, and in such cases the entire weight of fill above the culvert shall be considered as carried by the culvert.

The side pressure on the culvert wall shall be assumed to be equal to that on a retaining wall supporting a back fill equal in height to the culvert wall.

IV.—UNIT STRESSES.

64. The **Bearing** of masonry plates on concrete shall not exceed 400 lbs. per square inch.

65. The **direct compressive stress** in massive concrete shall not exceed 400 lbs. for 1-3-6 concrete or equivalent, nor 500 lbs. for stronger concrete.

66. The **Compression** stress in reinforced concrete due to bending shall not exceed 750 lbs. per square inch on 1-2-4 stone or gravel concrete as hereinafter specified, nor 650 lbs. per square inch on slag concrete, when computed by the straight line formula.

NOTE: This unit stress of 750 lbs. per square inch determined by the straight line formula as used in these specifications is equivalent to 630 lbs. when determined by the parabolic formula, assuming the same conditions, and the actual factor of safety is correspondingly greater than the apparent factor of safety.

67. The direct compression on concrete in reinforced **Columns** whose length does not exceed 18 times the diameter or least side, shall not exceed 400 lbs. per square inch for 1-2-4 concrete or equivalent, unless hooped circular columns be used, in which case the unit stress may be increased 50 per cent provided that the amount of hooping be not less than 1 per cent of the vertical section and that longitudinal bars be provided equal in area to at least 1 per cent of the horizontal section and that the concrete area enclosed by the hooping be considered as the effective area of concrete in compression.

68. The compressive stress on 1-2-4 natural cement concrete must not exceed 200 lbs. per square inch.

69. The **Shearing** stress on concrete shall not exceed 50 lbs. per square inch for massive concrete nor 60 lbs. per square inch for 1-2-4 stone reinforced concrete nor 50 lbs. for 1-2-3 slag reinforced concrete.

70. The **Adhesive** stress of concrete to plain steel bars shall not exceed 60 lbs. per square inch for 1-2-4 stone concrete, nor 50 lbs. for 1-2-3 slag concrete. When **Deformed Bars** are used, these values may be doubled.

71. The stress on **Steel** reinforcing bars in **Tension** shall not exceed for soft steel 14,000 lbs. per square inch, for medium steel 16,000 lbs. per square inch, for high steel having an elastic limit of at least 40,000 lbs. per square inch, 20,000 lbs. per square inch.

72. The maximum allowable stress on **Steel in Compression** shall not exceed the maximum co-existing stress in the contiguous concrete multiplied by the ratio of the modulus of elasticity of the steel to that of the concrete. (See Art. 42.)

73. The maximum allowable loads on **Foundations** shall, unless otherwise indicated, be taken as follows:

On dry coarse gravel, well cemented, five tons (10,000 lbs.) per sq. ft.

On dry hard fine sand, four tons (8,000 lbs.) per sq. ft.

On dry hard clay, three tons (6,000 lbs.) per sq. ft.

On wet sand, two tons (4,000 lbs.) per sq. ft.

On wet clay, one ton (2,000 lbs.) per sq. ft.

The maximum allowable load on foundation material other than that given will be determined for each individual case by the Engineer in charge.

74. In the case of **Reinforced Steel Construction,** in which the steel frame, when not encased in concrete, is designed to carry a definite portion of the loads, the unit stresses in the steel frame, when carrying its portion of the load alone, must not exceed those allowed by the specifications of the American Bridge Co. for similar class of structure, and the unit stresses in the steel and concrete after completion shall not exceed those given herein for reinforced concrete construction. (See Art. 129.)

75. The stresses in timber framing for forms and centers must not exceed the unit stresses allowed by Watson's Specifications for timber construction. (See Appendix F.)

V.—QUALITY OF MATERIALS.

76. All **Cement** shall be, unless otherwise specified, American Portland cement of a well-known and tried brand. If so specified, Pozzulan Cement (some-

times called slag cement) may be used for concrete work under-ground such as footings, etc., where it is not subjected to the action of the atmosphere, and for concrete work constantly immersed in water. All cement shall be purchased subject to the Standard **Tests** of the American. Society for Testing Materials as adopted November 14, 1904, and as may be subsequently amended (see Appendix A) and these tests shall be made in strict accordance with the methods prescribed by the Committee on Uniform Tests of the American Society of Civil Engineers. Tests shall be made from at least each car load of cement and no cement shall be used on the job until such tests shall have been made. Cement must be ordered sufficiently in advance of its use to allow at least 28 days for testing.

77. **Pozzulan Cement** if used will be understood to mean cement made directly from blast furnace slag and lime without calcination subsequent to the mixing. It must be used only under water or in other places where thoroughly protected from the atmosphere. It must weigh not less than 330 lbs. per barrel and it shall meet the fineness, soundness and setting tests as prescribed for true Portland cement and shall have a specific gravity of not less than 2.7 and must develop a tensile strength not less than 75 per cent of that specified for Portland cement.

78. True Portland cement made from blast furnace slag will be classed with other Portland cements.

79. **Stone** for massive concrete work shall be crushed sandstone, limestone, granite, trap, or other suitable hard stone in graded sizes of 1/4 to 2-1/2 inches.

Stone for reinforced work shall be of similar material but in graded sizes of from 1/4 to 1 inch.

For very large masses of reinforced concrete such as large beams and girders, stone up to 1-1/2 inches may be used and for very small work 3/4 inch shall be the maximum size.

80. **Sand** shall be clean, hard and free from more than 5 per cent of loose earth or loam or other foreign matter, and entirely free from impurities adhering to the surfaces of the grains of sand.

81. **Gravel** for reinforced concrete work shall be clean graded gravel in sizes as specified for stone. No soft stone, shale or other materials subject to disintegration will be allowed. When gravel is not well graded or not uniform, the Engineer will determine the proportions for each grade brought upon the work, so as to give results equivalent to those of the specified mix, or may require all gravel to be screened, at his discretion.

82. **Slag** for concrete work shall be crushed slag in sizes similar to those specified for crushed stone and shall be nearly free from sulphur or other injurious agents and must be hard and not spongy.

83. All stone, gravel or slag shall be screened, unless otherwise distinctly arranged with the Engineer and shall be subject to the Engineer's acceptance.

84. **Steel** for reinforced concrete and reinforced steel construction shall be medium open hearth steel, manufactured in accordance with the Manufacturers' Standard Specifications for this grade of material as revised February 3, 1903, and subject to subsequent revisions of the same. It shall be purchased subject to the usual tests as specified in the Standard Specifications above mentioned. It shall have an ultimate strength of from 60,000 to 70,000 lbs. per square inch, and an elastic limit of not less than one-half the ultimate strength. It shall be capable of being bent 180° to a diameter equal to the thickness of the piece tested without fracture on the outside of the bent portion. It shall contain not over .08 per cent of phosphorus.

85. **High Steel** shall be made by the Open Hearth process, shall contain not over 0.08 per cent of Phosphorus, .08 of Sulphur, and not more than 0.08 per cent nor less than 0.40 per cent of manganese.

The ultimate tensile strength shall be not less than 90,000 lbs. per square inch and the elastic limit (yield point) not less than one-half the ultimate strength.

The elongation in eight inches shall be not less than 10 per cent.

For materials less than five sixteenths in (5/16″) and more than three fourths inch (3/4″) the thickness the following modifications shall be made in the requirements for elongation.

(a) For each increase of one eighth (1/8″) in thickness above three fourths inch (3/4″) a deduction of one per cent (1 per cent) shall be made from the specified elongation.

(b) For material from 1/4 inch to, but not including, 5/16 inch thick, the elongation shall be 8 per cent.

For material from 3/16 inch to, but not including, 1/4 inch thick, the elongation shall be 7 per cent.

For material from 1/8 inch to, but not including, 3/16 inch thick, the elongation shall be 6 per cent.

For materials less than 1/8 inch thick, the elongation shall be 5 per cent.

Bending Test—Test specimens for bending shall be bent cold around a diameter equal to their thickness to the following angles without fracture on the outside of the bent portion.

For specimens 1 inch thick 80°. For specimens 3/4 inch thick 90°.

For specimens 1/2 inch thick 110°. For specimens 1/4 inch thick 130°.

For specimens 3/16 inch thick 140°. For specimens 1/8 inch thick 160°.

Wherever practicable, the standard test specimen used and described in the Manufacturers' Standard

Specifications for medium steel shall be used in making tests.

The bending tests will be preferably made by slowly applied pressure.

Check analysis for chemical composition may be made from drillings.

Bessemer Steel shall not be used except by special arrangements with the Engineer, and when used the amount of Phosphorus shall not exceed 0.10 per cent and it shall meet all other requirements as given herein for Open Hearth Steel.

86. Medium steel which has been subjected to **Twisting** or other treatment such as to raise its ultimate strength and elastic limit to that given for high steel may be considered as equal to high steel and may be bent and may be used in railroad and electric railway structures if it meets the bending test prescribed in Art. 84.

87. Unless otherwise shown on the drawings all reinforcing steel shall be **Plain Round Bars,** and in case deformed bars are specified they shall be of the section as specified on the drawings, or in case the drawings do not state what form of deformation is to be used, the Contractor shall furnish bars which will be satisfactory to the Engineer.

88. **Deformed Bars** will be used in all cases where it is not possible to develop the strength of the plain bar by adhesion, and will be **preferred** in all railroad and electric railway structures.

VI.— PROPORTIONING, MIXING AND PLACING.

89. All concrete **Proportions** specified herein will be based upon the assumption that one barrel of Portland cement is equivalent to 3.8 cubic feet and all pro-

portioning must be done by means of a carefully gauged wheelbarrow or other apparatus of capacity which will be determined by the Engineer.

QUANTITIES OF MATERIALS REQUIRED FOR ONE CUBIC YARD BY SPECIFIED PROPORTIONS.

Mix No.	Proportion	Cement in Barrels	Sand cu. yds.	Stone, Slag, or Gravel —cu. yds.
4-1/2	1—1-1/2—3	2.00	0.42	0.84
5	1—2—3	1.81	0.51	0.76
6	1—2—4	1.57	0.44	0.88
7-1/2	1—2-1/2—5	1.30	0.46	0.92
9	1—3—6	1.11	0.47	0.94
11-1/2	1—3—6+1/4 Rubble	0.83	0.37	0.72
10-1/2	1—3-1/2—7	0.89	0.47	0.95
13	1—3-1/2—7+1/4 Rubble	0.68	0.35	0.71

Based on 3.8 cubic feet per Bbl. of Portland cement.

(See Articles 113, 114, 115 and 116.)

90. All **Mixing shall** be by machinery except such hand mixing as may be allowed by special arrangement with the Engineer.

91. If concrete is mixed by **Hand** the sand and cement shall be spread upon the mixing board in thin layers and turned with spades until the mixture is of uniform color. Stone and water shall then be added and the mix shall then be turned at least three times, not counting the shoveling off the board.

92. Preference will be given to revolving batch **Machines** which automatically measure the ingredients of the mix. Mixing must be very carefully and thoroughly done. Enough water must be used to make the mass plastic enough to run freely, in other words, a wet mix will be required for all reinforced concrete work.

For massive concrete work, only enough water will be used to make the concrete plastic, not so wet but that it may be churned with a light tamper sufficient to quake the mass.

93. The concrete shall be **Placed** in position immediately after mixing and before the initial set shall have taken place.

94. No **Retempering** of concrete which has been allowed to stand until the initial set has taken place will be allowed unless by special permission of the Engineer who may, at his discretion, require additional cement to be used in retempering.

95. The mixing and placing of concrete will be as far as practicable a continuous operation, and when it is necessary to make a **Joint** in monolithic concrete, it shall preferably be made in the middle of a panel at right angles to the beams and by means of a stop board placed in a vertical position and containing a key on the side next the concrete first placed. When these stop boards are removed, the exposed surfaces of concrete shall be wet and carefully dusted with neat cement or painted with mortar before continuing the next block.

When it is necessary to **Bond** new concrete to concrete partially or wholly set, the Engineer may require that the surface of the old concrete be roughened, either by picking or by washing with acid, thoroughly rinsing same off, and applying a thin coat of rich cement mortar 1 to 1, or a bonding preparation may be used, by permission of the Engineer.

96. Concrete must be kept wet for one week after depositing and in dry hot weather must in addition be kept covered from exposure to the sun during this time, or else must be constantly sprinkled during the day by a workman especially detailed for this work.

97. **Natural Cement** concrete will only be used, if at all, in foundations underground and for the center

or core of massive structures, and when so used, Mix No. 6 will be used unless otherwise specified.

98. When it is necessary to place **Concrete under Water,** the structure should be encased with a cofferdam or other means taken to procure quiet water and then the material should preferably be deposited from a bucket provided with a bottom dump, or a tremie may be used. Care must be taken to keep the deposited concrete as nearly horizontal as possible when depositing under water.

99. When the concrete must be deposited in running water it will be done by placing the concrete in bags and depositing the bags in place or by other means equally satisfactory to the Engineer.

100. Unit stresses on concrete deposited as per Article 98 must be decreased 33-1/3 per cent, and when deposited as per Article 99, 50 per cent.

101. In heavy foundation work or other work requiring large masses of concrete, the Contractor may use not to exceed 25 per cent of one-man stones to imbed in the concrete. Such stones must be sound, clean and wet before placing and shall not be placed nearer than one foot from the surface of the concrete. They must be laid with their largest face down.

VII.—INSPECTION AND TESTS.

102. All materials will be subject to inspection by the Engineer in charge or his authorized assistant, and to such tests as the Engineer may make.

103. The Engineer may in addition to the Standard Tests of Cement (See Appendix A) cause to be made, **Short Time Tests of Cement** in contingencies where it may become desirable to use the cement before it is possible to complete the standard tests, but unless otherwise arranged in writing, the Contractor will remain responsible for the quality of the cement until

the same is accepted by the Engineer after making the final tests.

Short time tests shall consist of the frequent preparation of pats and balls of cement and mortar and the approximate determination of the time of setting and of the strength from them. Some of the pats will be put into water as soon as sufficiently set and the water raised to the boiling point and allowed to boil for two hours. The quality may then be judged by the appearance and by the fracture. In addition the Engineer may cause to be determined by the usual methods, the weight and fineness of the cement. The Engineer may at his discretion give the Contractor written acceptance of the cement on the results of such tests only.

104. The Engineer will have an Inspector on the work, whose duties will be to see that these specifications, the plans and contract are faithfully fulfilled and that all work is of a strictly first-class character. (See Art. 230.)

105. On the completion of the work and before its acceptance, the Engineer may cause **Final Tests** to be made at the Contractor's expense, by loading the structure with twice the specified live load, applied statically, or with the specified live load applied at the highest rate of speed.

These tests will not be made on concrete less than thirty days old, and the static loads shall remain in place not less than 24 hours. Under such loads there shall be no perceptible cracking of the concrete in tension, no deflection of beams exceeding in amount one-three-hundredth part of the span, nor any other indication of weakness in any part of the structure.

106. In the event of the partial or total failure of the structure under final tests, or under any other conditions during construction, then the responsibility of the failure or defect shall be fixed by agreement be-

tween the Engineer and the Contractor, or in the event of their failure to agree, by the Board of Arbitration provided for herein, and if the Contractor be held responsible, he shall make good all such defective work and if he be not held responsible, the Owner shall pay for all such extra work at cost to the Contractor.

107. In the event of failure of any part of the structure under test, the Engineer may require tests to be made of all such other parts as he may deem advisable, the expense of such tests to be borne by the party held responsible for the failure.

108. When the Contractor is responsible for the design as well as the construction of a structure, he alone will be held responsible for all failures under tests or during construction.

VIII.—CONCRETE SLAB, BEAM, GIRDER AND COLUMN CONSTRUCTION.

109. Reinforced concrete **Slabs** will preferably be used for all spans up to about fifteen (15) feet and reinforced concrete slabs supported by beams and girders for all spans from 15 to 30 or 40 feet depending upon conditions of loading and supporting.

110. Reinforced concrete slabs will also be preferred for the floor system of steel bridges.

111. Reinforced concrete slab, beam, girder and column construction will be preferred for elevated railroads, highway viaducts, especially where same cross railroad tracks, trestle construction, etc.

112. Reinforced concrete for slab, beam, girder and column construction and for all other types of reinforced concrete construction will, unless otherwise specified, be proportioned as follows: for carefully screened stone or gravel concrete, one part Portland cement, two parts sand and four parts broken stone, Mix No. 6; for slag concrete one part Portland cement,

two parts sand, and three parts slag, Mix No. 5. The materials to be of the quality and sizes as herein described. (See Article 89.)

113. The sizes of broken stone or slag for use in reinforced concrete work must not exceed one and one-half inch for large work nor three-quarters inch for small work.

114. If other materials than carefully screened broken stone, slag or cinders and sand as herein described (See Art. 79) be used, the proportions shall be subject to such **Changes** as shall be found to give equivalent results in strength and density to the results obtained by use of the specified proportions and materials.

115. It is understood that these proportions and all other proportions given in these specifications are approximate only and subject to such changes as may be found necessary in order to obtain properly proportioned mixtures after the Engineer shall have caused to have made careful analysis of the materials proposed to be used by the Contractor. Such adjustment of proportions will not be made, however, for any other purpose than that of properly filling the voids in the sand and stone.

116. In case such adjustment of the proportions entails a larger proportion of cement to aggregate than that specified, the Contractor will be allowed the actual cost, delivered at the mixer, of such additional cement, the amount to be determined by using the amount as given in the table under Art. 89 as a basis. In case a less amount of cement be required, a corresponding amount shall be deducted from the contract price.

117. All steel for reinforcing must be placed with great care, all abrupt bends must be avoided except where one steel member is bent around another, or where the ends of main bars or stirrups are bent at right angles to provide an anchorage in the concrete,

and in such cases the value of the anchorage will not be taken greater than the compressive load on the concrete, equal to the allowable unit compression on concrete multiplied by twice the square of the least side or diameter of the bar. Vertical stirrups must always pass under the main tension bars, or be rigidly attached thereto.

118. The minimum distance from the surfaces of the concrete to the steel shall be two inches for columns, 1-1/2 inches for girders and beams, 1 inch for slabs six inches and more in thickness and 3/4 inch for slabs under six inches thick. (See Art. 53.)

119. Main bars in slabs shall be spaced a distance apart not to exceed two times the thickness of the slab, and cross bars shall always be used at right angles to the main carrying bars. Cross bars shall not be less than 1/4 inch diameter and spaced a distance apart not to exceed twice the specified maximum distance for main carrying bars.

120. The clear distance between reinforcing bars shall never be less than one and one-half times the maximum diameter of stone or bar used.

121. In the case of columns containing longitudinal reinforcing bars proper provision must be made for splicing such bars without any reliance upon the concrete for transmitting stress from one bar to another, and at the base of the column proper provision must be made for transmitting the load carried by the reinforcing rods into the concrete of the footing without overstressing the concrete.

122. Column bars must be tied together by horizontal hoops not less than 1/4 inch diameter and not farther apart than 24 inches. The distance between spirals or hoops in hooped columns shall not exceed ten times their diameter or vertical side.

123. Wherever **Bolts** are to be imbedded in the concrete, these bolts will be furnished by the Owner and placed in position by the Contractor.

124. The Contractor for concrete work must place all anchor-bolts for columns, beams, etc., and must place all anchors and ties for all attachments to the concrete work, such as terra cotta or cast concrete trimmings and facings, brick facings, etc.

125. Wherever **Pipes, Wires, Conduits,** or other fixtures not otherwise provided for herein, are to be encased in the concrete work, they shall be furnished and placed under another contract, unless otherwise provided for on the plans or in the contract.

126. When reinforced concrete columns are exposed to probable injury by vehicles, etc., they will be protected for a height of four feet from the ground, preferably by metal forms of structural steel or cast iron.

127. When **Through Girders** or beams carry slabs or beams attached near the lower edge, they must be provided with stirrups at such points sufficient to carry the applied load to the upper part of the girder, such stirrups to be suitably anchored to the slab or beam.

IX.—REINFORCED CONCRETE TRUSSES.

128. **Reinforced Concrete Trusses** will be designed in such a manner that the tensile stresses will be entirely resisted by the steel and the compressive stresses as far as practicable by the concrete.

As far as possible, they will have no eccentric connections, and the tension bars must be anchored at the connections in such a way as to develop their full stress without producing bending moment about the joints, unless such moments be carefully determined and provided for.

Contractors submitting plans for reinforced concrete trusses must submit complete stress diagrams giving all sizes of material and all stresses.

X.—REINFORCED STEEL CONSTRUCTION.

129. When the steel reinforcing is so designed that it will carry in itself, without support from the encasing concrete, a definite proportion of the load, all parts of the steel construction shall be designed to carry such load, using the specifications of the American Bridge Co. for unit stresses and workmanship. (See Art. 74.)

130. In addition to its portion of the specified loads, the steel frame must also be proportioned to provide for all bending stresses due to the negative bending moment, in the case of partially continuous construction, or the bending moments due to eccentric loads.

131. The steel must also be sufficient to resist all tensile stresses due to the full load.

132. The concrete must be so proportioned as to provide the additional resistance required for the balance of the load.

133. Unless special provision is made to develope continuity, all beams and girders of reinforced steel construction shall be computed as simple beams.

134. **Forms** for reinforced steel beams, girders and columns may be removed in two-thirds (2/3) the time specified for monolithic reinforced concrete construction.

XI.—REINFORCED CONCRETE UNIT CONSTRUCTION.

135. When slabs, beams, girders, or other parts are made in units in an established factory, the formulae given herein for the design and proportioning thereof may be disregarded, at the option of the Engineer, and the results of tests may be used.

In such cases all units shall be subject to testing under the direction of the Engineer at the Contractor's expense, the number of such tests and manner of testing to be agreed upon between the Contractor and the Engineer. All such tests must show a safe carrying capacity equal to at least three (3) times the specified live loads, without cracking the concrete on the tension side, and an ultimate capacity of at least five times the specified live load.

XII.—CAST STONE AND BLOCKS.

136. **Cast Stone** will be preferred for ornamental work, balustrades, parapets, etc., and concrete building blocks may be used for spandrel walls of arches, etc.

137. **Cast Stone** will preferably be cast in a sand mould in an established factory, and should be tooled by means of revolving carborundum wheels or similar devices used in such factories to remove the skin coat.

138. If tamped into a rigid mould, tooling will always be required.

139. When any cast stone exceeds in any dimension six times it least dimension, it must be properly reinforced to insure safety in handling.

140. The proportion of cement to aggregate in cast stone and blocks must not be less than one to six, nor greater than one to four and the aggregate must not be too fine, but should be of graded sizes from 3/8 inch diameter down.

141. **Building Blocks** must be strong, well cured, dense, have good edges and must show a strength of at least 1200 lbs. per square inch at twenty-eight days.

142. The Contractor will furnish and place on file with the Engineer, with the bid, **Samples** of the concrete blocks and cast stone proposed to be used, which shall be satisfactory to the Engineer, and the blocks and stone used must conform in every way to such samples.

143. No broken, chipped, or checked blocks or castings will be allowed to be used in the work and all blocks or castings must be carefully protected from injury. By checked blocks are meant blocks showing fine hair checks on the surface.

144. All cast stone must be provided with suitable **Dowels** and anchors for securing same to the work and all cast stone and blocks must be laid up in white or non-staining Portland cement mortar.

XIII.—CONCRETE ARCHES.

145. All **Arches** must be computed and proportioned in accordance with the regulations given under sections III. and IV. and complete stress diagrams must accompany all plans.

146. All arches must be assumed to be subject to a **Range of Temperature** equal to plus or minus thirty degrees from that at which the concrete is laid, and provision must be made for expansion and contraction due to this change at the crown and at the piers.

147. In general the following proportions will be used in Arch Construction:

(a) for the **Arch Ring,** for light spandrel walls, for light spandrel arches, etc., one part Portland cement to two parts sand to four parts stone, Mix No. 6. (See Art. 89.)

(b) for **Heavy Spandrel Walls,** and for light piers, and wing walls, one part Portland cement to two and one-half parts sand, to five parts stone, Mix No. 7-1/2.

(c) for **Heavy Piers,** wing walls, etc., of massive concrete, one part Portland cement to three parts sand to six parts stone, in which may be imbedded twenty-five per cent of one-man stones. Mix No. 11-1/2.

(d) for **Heavy Footings** of massive concrete, one part Portland cement to three and one-half parts sand to seven parts stone, in which may be imbedded twenty-five per cent of one-man stones, Mix No. 13, or Mix No. 11-1/2 may be used with Puzzolan cement (see Art. 89) or Mix No. 6 with natural cement. (See Art. 114, etc., for adjustment of proportions.)

148. In general the arch rings of concrete arches will be laid in **Transverse Sections**, laying the crown section first, then the sections at the quarter points and filling in between. The voussoirs thus formed must be provided with **Keys** equal in depth to one-quarter of the depth of the arch ring.

149. The reinforcing **Steel** for reinforced concrete arches shall not be less than three-quarters of one per cent of the crown section.

150. The **Spandrel Walls** should be securely anchored to the arch rings by means of proper dowels, and the arch ring reinforced transversely sufficiently to provide for the maximum lateral thrust on the spandrel walls.

151. The spandrel walls will preferably not be concreted until the wedges have been struck from under the centering.

152. Reinforcing bars for arch rings must extend below the springing plane a sufficient distance to develop the full strength of the bar by adhesion. (See Art. 70.)

153. All arches must be waterproofed.

154. In case **Hinged Arches** are used, the hinges will preferably be of annealed cast steel, imbedded as much as practicable in the concrete and effectively anchored thereto.

155. In case **Ribbed Arches** are used, each rib shall be considered as a beam to resist the bending stresses and the thrust, and in case full spandrel braced concrete arches are used, the spandrels shall be considered only as assisting in the resistance to bending and the rib shall be sufficiently strong to resist the

direct thrust. In the case of full spandrel braced arches the span and rise may be taken as the span and rise of the intrados.

XIV.—RETAINING AND SEA WALLS.

156. **Retaining Walls** will be designed to resist a horizontal thrust equal to that given by Rankine's formula (see Appendix G) which will be assumed to act at a point one-third the height of the wall above the footing. (See Articles 56 and 57.)

No allowance will be made for the friction at the back of the wall, but the weight of the filling material resting on all offsets, footings, etc., will be considered. Unless otherwise specified, the weight of earth filling will be taken at 100 lbs. per square foot.

157. **Sea Walls** or other retaining walls which may be subjected to saturation of the back fill shall be proportioned to resist the fluid pressure due to the action of a fluid equal in weight to the weight of the filling material.

Sea walls subject to wave action must be proportioned to resist the pressure of a head of water equal to twice the greatest wave height.

XV.—CONCRETE ABUTMENTS.

158. Massive concrete abutments will be preferred for all cases requiring a heavy mass, and reinforced concrete in cases when heavy mass is not required.

159. The type of abutment to be used, whether wing, straight, T or U type will be indicated on the drawing.

160. All abutments must be designed to resist the thrust of the backing, in combination with such other forces as may come upon them, without exceeding the unit stresses given under Section IV.

161. In assuming the angle of repose of the back filling, a slope of 1 vertical to 1-1/2 horizontal shall be assumed for loose dry earth or sand and a slope of 1 to 1 for carefully laid and compacted dry earth filling.

162. All abutments must be carefully drained, or if not possible to do this, they must be proportioned to resist the action of fluid pressure due to the back fill.

163. The faces of abutments will be given a **Batter** unless otherwise shown on the plans, of three-quarters of an inch to the foot, and there will be provided a coping course under the bridge seat in the case of abutments for steel bridges, which will unless otherwise shown on the plans be sixteen inches deep and project four inches.

164. Backwalls for abutments of steel bridges must have a thickness at the base of at least one-half their height or else be reinforced.

165. In general, concrete for abutments will be mixed in the proportion of 1 part Portland cement to three parts sand to six parts broken stone, Mix No. 9, for massive concrete and subject to the same conditions as specified under Article 114.

Natural cement concrete, Mix No. 6, may be used for foundations or in other places where it will not be subjected to the action of the atmosphere nor to running water.

The **Bridge Seats** shall be Mix No. 4-1/2 concrete of Portland cement one part, hard sand one and one-half parts, and hard stone three parts.

166. All **Anchor Bolts** for steel superstructure when used shall be furnished by the Owner and set by the Contractor.

XVI.—CONCRETE PIERS.

167. **Concrete Piers** will preferably be constructed of massive concrete in all cases where they are

liable to be submerged in water, in order to obtain the greatest possible weight.

168. The **Mixtures** to be used in concrete piers will be the same as those used in abutments.

169. The Pressure of ice against concrete piers must be considered and shall be taken as equal to the water line on the exposed side into the maximum depth of ice for that latitude and multiplied by 1,000 lbs. per square foot.

170. Piers must also be proportioned to withstand **impact** from floating logs, or other forces to which they may probably be subjected.

171. Piers shall be given a batter similar to that specified for abutments, also copings of similar construction and mixtures.

The hydraulic uplift of water penetrating underneath the footings of piers must be considered.

XVII.—CONCRETE FOOTINGS.

172. **Massive Concrete Footings** may be constructed of natural cement concrete, Mix No. 6, where they will not be exposed to the action of the air or running water, or they may be constructed of Pozzulan concrete, Mix 7-1/2, where not exposed to the air, provided that the maximum stresses do not in any case exceed the allowable unit stresses as given in section IV.

173. All footings will, wherever practicable, be laid free from water, and no concrete footings will be laid in water except by special arrangement with the Engineer.

174. Footings having heads of piles imbedded therein will have the contents of the imbedded piles deducted in computing contents of masonry.

175. **Reinforced Concrete Footings** will be designed in accordance with the provisions of Sections

III. and IV. but no reinforcing will be placed at a less distance than four inches from any concrete surface.

176. The reinforcing must be so arranged as to distribute the loads equally on the foundation.

177. Reinforced concrete footings must always be of Portland cement concrete Mix No. 6 or 7-1/2 as specified on the drawing.

178. In estimating the **Excavation** for footings, the size of excavations will be taken one foot larger all around than the size of the footings.

179. Unless otherwise agreed upon the price bid by the Contractor for footings, will include all **Sheeting, Pumping, Cofferdams,** etc., required to keep the pits free from water while depositing concrete, the removal of same, and backfilling to the original level of the ground.

XVIII.—CONCRETE PILES.

180. **Concrete Piles** will be divided into two classes; first, concrete piles moulded in forms and driven to place; and second, concrete piles formed in place. The former must be sufficiently reinforced to withstand handling and must be provided with proper cushions for driving and will be entirely at Contractor's risk. They must be driven to elevations as given by the Engineer, or else must be cut off to such elevations. Piles of the second class will preferably be of the "Simplex" or "Raymond" patented types, as indicated on the drawings.

181. The Contractor will **Test** at his own expense and under direction of the Engineer, the number of test piles called for by the plans, by loading to at least 1-1/2 times the specified live loads without exceeding a settlement of one-half inch, unless otherwise specified.

182. The ordinary **Formulas** for determining the bearing power of timber piles will not be applied to concrete piles.

183. If **Timber Piles** be used, they must be of the length shown on the plans, straight, free from wind shakes, or other defects which might impair their strength, and not less than ten inches diameter at the butt, nor less than six at the end.

They shall be of the kind of timber called for on the drawings or else hardwood piles shall be used, and unless otherwise arranged, be stripped of bark before driving.

XIX.—FORMS AND CENTERS.

184. All **Forms** for moulded concrete work will be constructed of sufficient strength to obtain the necessary rigidity to prevent any motion of the forms while concrete is being placed and must be strong enough to carry any load which may come upon the concrete within 30 days from the date of placing the concrete.

185. Forms shall in general be composed of tongue and grooved sheeting, if 7/8 inch sheeting be used, or carefully matched stuff if heavier sheeting be used. They must be as nearly as possible watertight and must be surfaced on the side next the concrete for all surfaces which will be exposed in the finished work.

186. Forms shall be constructed by experienced and capable workmen only, and must be true to line and grade and of first-class workmanship throughout.

187. The forms for all exposed surfaces of concrete must be smooth and the boards must be carefully matched. The surface next the concrete will be oiled, and forms used a second time must be carefully cleaned and oiled again.

188. The **Oil** to be used in oiling forms shall be thick and heavy enough to act as a filler for the forms. The

quality of oil known as "sludge" at the oil refineries, or its equal, is recommended.

189. Great care must be taken to clean all sawdust, dirt, or debris from forms just before placing concrete, and whenever necessary forms must be cleaned out by steam jet or equally effective means.

All forms shall be so constructed as to be readily **Cleaned.**

190. In general forms shall not be removed from concrete in less than 14 days in summer and 28 days in winter, except in the case of vertical surfaces, etc., which do not carry loads.

Forms must always be removed from columns before removing shores from beneath beams and girders, in order to determine the condition of the column concrete. The supports for any concrete member in which the dead load exceeds the live load shall not be removed in less than twice the limits of time given above.

191. **Centers** will not be struck from under arches in less than 28 days except in the case of arch culverts of less than 30 feet span.

192. But no forms whatever will be removed at any time without first notifying the Engineer in charge. But such notification shall not be considered to relieve the Contractor of responsibility for the construction and for the removal of such forms.

193. Wherever practicable, edges of beams, girders and columns will be **Chamfered** and sides of beams and girders will be splayed slightly in order that forms may be more readily removed.

194. All forms must be designed so that they may be removed with as little damage as possible to the concrete or to the forms.

195. All projecting wires and bolts or other devices that are used for holding forms and that pass through the concrete must be cut off at least one inch

beneath the finished surface and the ends covered with cement mortar of the same mix as used in the body of the work.

196. In proportioning forms and centering, concrete will be treated as a liquid of its full weight for vertical loads and one-half its weight for horizontal pressures.

197. The unit stresses used in proportioning forms must not exceed the limits given under Art. 75.

198. In constructing centers for arches of more than 30 feet span no reliance shall be placed upon spiking, but all main members must be bolted together at joints.

199. Wedges will have a slope of 1 to 10.

200. In constructing centers for arches, an allowance for settlement must be made equal to 3/4 inch for each 30 feet vertical height.

XX.—SURFACE FINISH.

201. If no surface finish be called for the surface of the concrete after removal of the forms will be gone over and all cavities, etc., filled with dry mortar of the same proportions as used in the original work.

202. If a **Rubbed Finish** be specified, as soon as the forms are removed the concrete surfaces shall be gone over with a piece of sandstone or carborundum about the size of a brick which will be used to grind down the surface of the concrete sufficiently to remove all impressions of the timber or other irregularities.

This sandstone will be dipped in a cement wash composed of one part cement to two parts of fine sand, or preferably this wash may be applied with a brush and the concrete immediately ground down with the sandstone.

203. If a **Washed Finish** be specified it shall be obtained by removing the forms within 8 or 10 hours after the concrete has been deposited, in warm weather, and

washing out the cement film. In doing this the supports for arches and floors of any part of the work where the concrete is subject to stresses shall not be removed but only the sheeting of the exposed surfaces which are to be treated.

204. If a **Dressed Finish** be specified for moulded concrete, it shall be obtained by dressing with a sharp bush hammer and washing with muriatic acid diluted about one-half and carefully rinsed off. This can be done after the concrete has thoroughly set.

205. If a **Tooled Surface** be specified the work shall preferably be done with pneumatic hammers or such other tools as are ordinarily used for similarly dressing stone surfaces.

206. Other methods of exterior finish may be used providing same are specified in the contract or agreed upon between the Contractor and the Engineer; or if so agreed upon the exterior finish may be omitted entirely.

207. Unless called for on the drawings there will be no **Mortar Facing** used in this work but great care must be taken to insure the flushing of the cement against the forms. This shall be done by careful spading and puddling of the plastic concrete for which special tools shall be provided as required.

208. In case a mortar face is called for, it shall be mixed of specially selected materials which shall be uniform as possible for the entire job and which shall be mixed in the proportion of one part cement to three parts sand or screenings; (crushed marble screenings will be preferred for facing mortar and unless otherwise specified this shall be used.) These screenings or sand must not be too fine but should be from 1/4 inch diameter down.

209. The finish of **Ornamental Work** such as balustrades cast in pieces or blocks shall preferably be obtained by casting same in a sand mould and with

a facing of crushed marble or granite of a suitable color. After removal from the moulds they should be tooled by means of revolving carborundum wheels or similar devices to remove the skin coat of cement.

210. Finish of the balustrade should be finer than that of the balance of the work.

Fine mouldings or other ornamental work shall always be made with a mortar face.

XXI.—WATERPROOFING.

210. Waterproofing will be of three classes; first, that obtained by mixing with the cement a waterproofing compound consisting of an impalpable material; second, that obtained by means of covering the concrete with a waterproof coat of asphalt; and third that obtained by means of laying impregnated paper or felt against the concrete surface, called the "membrane system."

211. In waterproofing by means of **Mixing** with the cement a waterproofing substance it shall be done by mixing not less than one per cent of Medusa Compound or similar waterproofing compound with each sack of cement.

212. If waterproofing by means of a coating of **Asphalt** be specified, the work shall be done as follows: The surface to be coated shall be painted with asphalt reduced with naptha; then a thin layer of hot asphalt shall be applied and thoroughly mopped over; then a coat of asphalt and clean dry sand in the proportion of one part asphalt to three parts sand by volume; this coat to be thoroughly mixed in the kettle and spread on with warm smoothing irons, the finishing coat to consist of pure hot asphalt spread thinly and evenly over the surface and then sprinkled with gravel. The finished coat shall be 3/4 inch thick.

All asphalt shall be of the best grade, free from coal tar or coal tar products. It must not volatilize more than one-half of one per cent under a temperature of 300° Fahr. for 10 hours. It must not be affected by 20 per cent solution of ammonia; 35 per cent solution of hydrochloric acid; 25 per cent solution of sulphuric acid nor by a saturated solution of sodium chloride. It must not flow under 185° Fahr. nor become brittle above zero degrees Fahr.

213. If tarred felt or similar waterproofing or the **"Membrane System"** be specified, the work will preferably be 4 ply Hydrex felt or equal cemented by Hydrex compound as manufactured and sold by the "Hydrex Felt and Engineering Co." or equal. It shall be laid in place with careful provision for lapping, drainage and flashing.

If the **Alum and Soap** method be specified a 5 per cent solution of ground alum and water shall be prepared, and a 7 per cent solution of soap and water. The alum solution shall be mixed with the mortar to the amount of 1/2 the ordinary gaging water. The soap solution shall then be applied in amount required to obtain the desired plasticity. (From Prof. Hatt.)

214. Instead of the above standard methods of waterproofing, the Engineer may require, if specified, the addition of alum to the mixing water, and finely pulverized colloidal clay to the cement, in the proportion of 2 per cent to the former and 10 per cent to the latter, or mixing water may be used carrying about 5 per cent of thoroughly hydrated lime. If lime be used great care must be taken to insure the complete hydration of the lime.

215. **Expansion Joints** will always be waterproofed, preferably by keys of asphalt in the case of walls, or by lead covers and filling of asphalt, or by covering carefully with felt layers if the membrane system be used.

XXII.—PAVEMENTS AND FOOT WALKS.

216. **Pavements** on bridges will be as shown on the plans and if the bridge is located in a municipality having standard specifications for pavements of that class, then such pavements shall conform in every respect to the requirements of such specifications.

If no such standard specifications exist, then the brief specifications given in Appendix C shall be used.

217. **Footwalks** on bridges will preferably be built with a finish coat one-half inch thick placed on the concrete base before the latter has set.

The finish coat will be composed of one part Portland cement to two parts of hard selected sand or crushed rock, preferably trap or granite. This finish will be screeded with a straight edge to grade, smoothed with a wooden float, and marked off into blocks of suitable size.

Troweling with a steel trowel will not be allowed unless by special permission of the Engineer.

XXIII.—FREEZING WEATHER.

218. No concrete will be laid in freezing weather except by special arangement and under supervision of the Engineer in charge. In case it becomes necessary to lay concrete in freezing weather, special arrangements must be made for heating all of the materials and maintaining a temperature which will not allow the concrete to freeze until it has set.

XXIV.—CONTRACTOR'S PLANS.

219. Contractors submitting their own plans for any class of reinforced concrete work covered by these specifications must submit complete drawings showing the size of each member in the proposed work and the arrangement of all the members. Such plans must conform to all of the assumptions for computing, allowed unit stresses, and requirements of general construction given by these specifications.

XXV.—GENERAL CONDITIONS AND CONTRACT CLAUSES.

220. If required by the Owner, the Contractor shall furnish a **Bond** in the sum of one-fourth of the amount of his contract with a satisfactory surety company as surety that the contract will be fulfilled.

221. Should there be any **Discrepancy** between the drawings and specifications, between scale or full size drawings, or between scale of the drawings and the figures on the same, the matter shall be referred to the Engineer and his decision shall be followed.

222. The Engineer will give all datum lines and levels necessary for the prosecution of the work and be responsible for the accuracy thereof.

223. The Contractor shall give to the proper authorities all requisite **Notices** relating to the work in his charge and shall conform to all laws and ordinances affecting same, shall obtain all official **Permits** and licenses required and pay all proper fees for same and he shall pay for any other legal charges from city, county, state or federal officers.

224. The work shall be suitably protected by red cautionary lights at night and by watchmen if necessary.

225. The execution of the work will be entirely at the Contractor's **Risk** and he will be liable for its safety. The Contractor will be liable for all cases of **Personal Injury** which may occur during the progress of the work.

226. All **Royalties** for patents or claims for the infringement thereof that may be involved in the construction of this work shall be included in the contract amount and the Contractor shall satisfy all demands that may be made at any time for such royalties and be liable for any damages or claims for infringements of patents.

227. At periods not less than 30 days apart on the request of the Contractor, the Engineer will make **Estimates** of the value of material furnished and labor performed, and the amount of such estimates less 10 per cent will be paid the Contractor by the Owner within 30 days after such estimate has been presented for payment.

The **Final Payment** will be made in 60 days after the completion of the work and the acceptance thereof by the Engineer on behalf of the Owner.

228. Or if so stated in the contract, **A Single Payment** for the whole shall be made within thirty (30) days after the completion of the work and its acceptance by the Engineer on behalf of the Owner.

229. The Contractor shall remove from the site all debris and rubbish at such times as may be directed by the Engineer.

230. The Engineer will have an **Inspector** on the work, whose duties will be to see that these specifications, the plans, and the contract are faithfully fulfilled, and that all work is of a strictly first-class character.

The Inspector will have no jurisdiction over the workmen, but he will report all violations of the specifications, plans, or contract, or any departure from strictly first-class work to the Contractor or his highest representative on the work, verbally, and to the Engineer in writing.

If such defective work be not made good immediately after such verbal notification on the part of the Inspector, then the Engineer may give written instructions to the Contractor to make same good and any violation or disregard of such written instructions on the part of the Contractor will be considered to be a violation of the contract. (Subject to the Arbitration Clause.)

The Inspector will be paid by the Engineer or Owner and will receive no compensation from the Contractor.

231. The work will be done under the general direction and supervision of the Engineer and his interpretation of the drawings and specifications shall be final, subject to the provisions of Art. 237.

The Engineer will furnish such additional drawings and explanations as may be necessary.

232. No **Alterations** will be made in the work or plans except by written order of the Engineer and the amount to be paid by the Owner or allowed by the Contractor for such alterations must be stated in such order. Should the Owner and the Contractor fail to agree as to the amount to be paid or allowed, the work shall go on under the order required above, and the determination of said amount be submitted to arbitration as herein provided for.

233. Should the Contractor at any time refuse to supply a sufficiency of properly skilled workmen, or of materials of the proper quality, or fail in any respect to prosecute the work with promptness and diligence, or fail in performance of any agreements herein contained, such refusal, neglect, or failure being certified to by the Engineer, the Owner shall be at liberty, after three days written notice to the Contractor, to provide any such labor or materials and to deduct the cost thereof from any money then due or thereafter to become due to the Contractor under this contract; and if the Engineer shall certify that such refusal, neglect, or failure is sufficient ground for such action, the Owner shall also be at liberty to terminate the employment of the Contractor for the said work and to enter upon the premises and take posession, for the purpose of completing the work included under this contract, of all materials, tools, and appliances thereon, and to employ any other person or persons to finish the work,

and to provide materials therefor; and in case of such discontinuance of the employment of the Contractor, he shall not be entitled to receive any further payment under this contract until the said work shall be wholly finished, at which time, if the unpaid balance of the amount to be paid under this contract shall exceed the expense incurred by the Owner in finishing the work, such excess shall be paid by the Owner to the Contractor, but if such expense shall exceed such unpaid balance, the Contractor shall pay the difference to the Owner. The expense incurred by the Owner as herein provided either for furnishing materials or for finishing the work, and any damage incurred through such default, shall be audited and certified to by the Engineer, whose certificate thereof shall be conclusive upon the parties, subject to the Arbitration Clause. See Art. 237.)

234. Should the Contractor be delayed in the prosecution or completion of the work by the act, neglect or default of the Owner, of the Engineer, or of any other Contractor employed by the Owner upon the work, or by damage caused by fire or other casualty for which the Contractor is not responsible, or by general strikes or lockouts caused by acts of employees, then the time herein fixed for the completion of the work shall be extended for a period equivalent to the time lost by any or all of the causes aforesaid, which extended period shall be determined and fixed by the Engineer; but no such allowance shall be made unless a claim therefor is presented in writing to the Engineer within forty-eight hours of the occurence of such delay.

235. The Owner agrees to provide all labor and materials essential to the conduct of this work not included in this contract in such manner as not to delay it progress, and in the event of failure so to do, thereby causing loss to the Contractor, agrees, that he will reimburse the Contractor for such loss; and the Con-

tractor agrees that if he shall delay the progress of the work so as to cause loss for which the Owner shall become liable, then he will reimburse the Owner for such loss. Should the Owner and Contractor fail to agree as to the amount of loss comprehended in this article, the determination of the amount shall be referred to arbitration as provided in Article 237 of these specifications.

236. It is further mutually agreed between the parties hereto that no certificate given or payment under this contract, except the final certificate or final payment, shall be conclusive evidence of the performance of this contract, either wholly or in part, and that no payment shall be construed to be an acceptance of defective work or improper materials.

237. In case the Owner and the Contractor fail to agree in relation to matters of payment, allowance or loss referred to, or should either of them dissent from the decisions of the Engineer referred to, which dissent shall have been filed in writing with the Engineer within ten days of the announcement of such decision, then the matter shall be referred to a **Board of Arbitration** to consist of one person selected by the Owner, and one person selected by the Contractor, these two to select a third. The decision of any two of this Board shall be final and binding on both parties hereto. Each party shall pay one-half of the expense of such reference.

238. If the work be not completed on or before the date mentioned in the contract for such completion, then the Contractor shall reimburse the Owner for all losses or **Damages** or expenses, including expense of engineering and inspecting, to which the Owner may be subjected by reason of such delay.

239. The Engineer's drawings and these specifications are intended to be supplementary to each other and specifications given on the drawings shall have

full force as if given in the specifications, and in case of conflict between the two, specifications as given on drawings shall be taken as superseding these specifications.

240. The contract drawings shall be signed by both parties to the contract and shall be considered together with the specifications as part thereof.

241. All drawings prepared and notes obtained by the Engineer will remain the property of the Engineer unless otherwise specifically arranged with the Owner.

242. The Contractor will provide proper sanitary conveniences for the workmen.

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APPENDIX A.

STANDARD SPECIFICATIONS FOR CEMENT

AMERICAN SOCIETY FOR TESTING MATERIALS.

from the copyrighted Proceedings of the
Society. Vol. IV.

GENERAL OBSERVATIONS.

1. These remarks have been prepared with a view of pointing out the pertinent features of the various requirements and the precautions to be observed in the interpretation of the results of the tests.

2. The Committee would suggest that the acceptance or rejection under these specifications be based on tests made by an experienced person, having the proper means for making the tests.

Specific Gravity.

3. Specific gravity is uesful in detecting adulteration or underburning. The results of tests of specific gravity are not necessarily conclusive as an indication of the quality of a cement, but when in combination with the results of other tests, may afford valuable indications.

Fineness.

4. The sieves should be kept thoroughly dry.

Time of Setting.

5. Great care should be exercised to maintain the test pieces under as uniform conditions as possible. A sudden change or wide range of temperature in the room in which tests are made, a very dry or humid

atmosphere, and other irregularities vitally affect the rate of setting.

Tensile Strength.

6. Each consumer must fix the minimum requirements for tensile strength to suit his own conditions. They shall, however, be within the limits stated.

Constancy of Volume.

7. The tests for constancy of volume are divided into two classes, the first normal, the second accelerated. The latter should be regarded as a precautionary test only, and not infallible. So many conditions enter into the making and interpreting of it, that it should be used with extreme care.

8. In making pats, the greatest care should be exercised to avoid initial strains due to molding or to too rapid drying-out during the first twenty-four hours. The pats should be preserved under the most uniform conditions possible, and rapid changes of temperature should be avoided.

9. The failure to meet the requirements of the accelerated tests need not be sufficient cause for rejection. The cement may, however, be held for twenty-eight days, and a retest made at the end of that period. Failure to meet the requirements at this time should be considered cause for rejection, although in the present state of our knowledge it cannot be said that such failure necessarily indicates unsoundness, nor can the cement be considered entirely satisfactory simply because it passes the tests.

GENERAL CONDITIONS.

1. All cement shall be inspected.

2. Cement may be inspected either at the place of manufacture or on the work.

3. In order to allow ample time for inspecting and testing, the cement should be stored in a suitable weather-tight building, having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the Contractor, and a period of at least twelve days allowed for the inspection and necessary tests.

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 pounds of cement net. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

8. Cement failing to meet the seven-day requirements may be held awaiting the results of the twenty-eight day tests before rejection.

9. All tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society January 21, 1903, and amended January 20, 1904, with all subsequent amendments thereto.

10. The acceptance or rejection shall be based on the following requirements.

Natural Cement.

11. Definition. This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Specific Gravity.

12. The specific gravity of the cement thoroughly dried at 100° C. shall be not less than 2.8.

Fineness.

13. It shall leave by weight a residue of not more than 10 per cent on the No. 100 and 30 per cent on the No. 200 sieve.

Time of Setting.

14. It shall develop initial set in not less than ten minutes and hard set in not less than thirty minutes, nor more than three hours.

Tensile Strength.

15. The minimum requirements for tensile strength for briquettes one inch square in cross section shall be within the following limits, and shall show no retrogression in strength within the periods specified. (For example the minimum requirement for the twenty-four hour neat cement test should be some specified value within the limits of 50 and 100 pounds, and so on for each period stated.)

Neat Cement.

Age: 24 hours in moist air; strength, 50-100 lbs.

Age: 7 days (1 day in moist air, 6 days in water); 100-200 lbs.

Age: 28 days (1 day in moist air, 27 days in water; 200-300 lbs.

One Part Cement, Three Parts Standard Sand.

Age: 7 days (1 day in moist air, 6 days in water); 25-75 lbs.

Age: 28 days (1 day in moist air, 27 days in water); 75-150 lbs.

Constancy of Volume.

16. Pats of neat cement about three inches in diameter, one-half inch thick at center, tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at a normal temperature.

(b) Another is kept in water, maintained as near 70° F. as practicable.

17. These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, should remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Portland Cement.

18. Definition. This term is applied to the finely pulverized product resulting from calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent has been made subsequent to calcination.

Specific Gravity.

19. The specific gravity of the cement, thoroughly dried at 100° C. shall be not less than 3.10.

Fineness.

20. It shall leave by weight a residue of not more than 8 per cent on the No. 100, and not more than 25 per cent on the No. 200 sieve.

Time of Setting.

21. It shall develop initial set in not less than thirty minutes but must develop hard set in not less than one hour, nor more than ten hours.

Tensile Strength.

22. The minimum requirements for tensile strength for briquettes one inch square in section, shall be within the following limits, and shall show no retrogression in strength within the periods specified. (For example the minimum requirement for the twenty-four hour neat cement test should be some specified value within the limits of 150 and 200 lbs., and so on for each period stated.)

Neat Cement.

Age: 24 hours in moist air; strength, 150-200 lbs.

Age: 7 days (1 day in moist air, 6 days in water); strength, 450-550 lbs.

Age: 28 days (1 day in moist air, 27 days in water); strength, 550-650 lbs.

One Part Cement, Three Parts Sand.

Age: 7 days (1 day in moist air, 6 days in water); strength, 150-200 lbs.

Age: 28 days (1 day in moist air, 27 days in water); strength, 200-300 lbs.

Constancy of Volume.

23. Pats of neat cement about three inches in diameter, one-half inch thick at the center, and tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air in normal temperature and observed at intervals for at least 28 days.

(b) Another is kept in water, maintained as near 70° F. as practicable, and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for five hours.

24. These pats to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

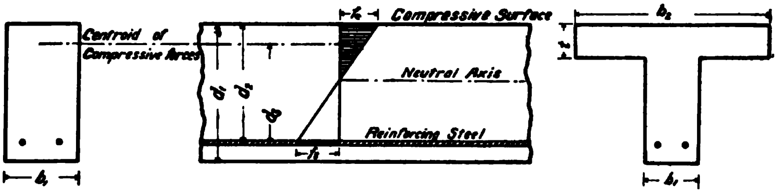
Sulphuric Acid and Magnesia.

25. The cement shall not contain more than 1.75 per cent of anhydrous sulphuric acid, nor more than 4 per cent of magnesia (MgO).

APPENDIX B.

ANALYSIS OF REINFORCED CONCRETE BEAMS.

Note: These formulae for moment of restistance and maximum stresses, etc., are based upon an assumed ratio of modulus of elasticity of steel to that of concrete equal to 15, in addition to all other assumptions specified under Sections III. and IV., and the specified proportions for stone or gravel concrete, Mix No. 6, or slag concrete Mix No. 5. In computing ratio of concrete area to steel area in T beams, the width is assumed to be b_2, the total width of the flange.



NOTATION.

d_1 = Total depth of beam.

d_2 = Distance from compressive surface to center of steel reinforcing.

$d_3 = Ad_2$ = Distance from centroid of compressive forces to center of steel.

A = Ratio of distance between centroid of compressive forces and center of steel to distance of center of steel below outside compressive surface of concrete.

x = Ratio of depth of neutral axis to depth of steel in tension.

xd_2 = Distance from compressive surface to neutral axis of beam.

b_1 = Width of simple beam or width of stem of T beam.

b_2 = Width of flange of T beam (See Art. 45).

t = Thickness of flange of T beam (Art. 45).

o = Periphery of reinforcing bars at any section.

a_1 = Area of steel tension bars at any section.

a_2 = Area of stirrups at any section.

a_3 = Area of steel compression bars at any section.

R = Ratio of cross-section of steel to cross-section of beam above the center of gravity of the steel.

s = Spacing of stirrups at any section.

M = Bending moment at any section from exterior forces.

m = Moment of resistance at any section.

S = Vertical shear at any section (See Art. 34).

f_t = Maximum fibre stress in steel in tension (See Art. 71).

f_c = Maximum fibre stress in steel in compression.

u_c = Maximum unit stress in concrete in compression (See Art. 66).

u_s = Maximum unit stress in concrete in shear (See Art. 69).

u_a = Maximum unit stress in adhesion of concrete to steel (See Art. 70).

E_s = Modulus of elasticity of steel.

E_c = Modulus of elasticity of concrete in compression.

$\frac{E_s}{E_c} = n$

(1) $x = -nR + \sqrt{2nR + (nR)}^{2}$

(2) $d_3 = d_2 \left(1 - \frac{x}{3}\right) = Ad_2$

(3) $a_1 = M \div Ad_2 f_t$

(4) $u_c = CMbd_2^2$

(5) $u_s = S \div Abd_2$

(6) $a_2 = S^1 \div f_t s$

where S^1 = excess vertical shear. (See Art. 34).

(7) $u_a = f_t a_1 \div oy$. (See Art. 70)

where y = distance to end of bar from point considered.

f_t = 16000 lbs. per sq. in. (See Art. 71) in medium steel.

= 20000 lbs. per sq. in. (See Art. 71) in high steel.

u_c = 750 lbs. per sq. in. (See Art. 66) in stone concrete.

650 lbs. per sq. in. (See Art. 66) in slag concrete.

u_s = 60 lbs. per sq. in. (See Art. 69) in stone concrete.
50 lbs. per sq. in. (See Art. 69) in slag concrete.
u_a = 60 lbs. per sq. in. (See Art. 70) on plain bars.
= 120 lbs. per sq. in. (See Art. 70) on deformed bars.

Bearing on concrete 400 lbs. per sq. in. (See Art. 64).

Compressive stress in massive concrete, 500 lbs. per sq. in. (See Art. 65).

Shear in massive concrete, 50 lbs. per sq. in. (See Art. 69).

Compression in concrete columns, 400 lbs. per sq. in. (See Art. 67).

Compression in hooped columns, 600 lbs. per sq. in. (See Art. 67).

Bending moment (M^1) in columns for partially continuous construction:

$$M^1 = \frac{W^1 L}{20}\left(\frac{d_6}{d_5}\right)^2 \quad \text{(See Art. 38)}$$

where W^1 = Live panel load
d_5 = effective depth of girder or beam transmitting load to column
d_6 = effective depth of column

COMPRESSIVE REINFORCEMENT.

When it is found necessary to provide reinforcement in the compression flange, the resisting moment of the beam, assuming the maximum allowable unit stress in the concrete of the compression flange and the corresponding percentage of steel in the tension flange shall be deducted from the total external bending moment, and the remaining moment (m^1) be provided for by introducing additional reinforcement in both flanges at the specified unit stresses in tension and compression. (See Art. 72).

$$m^1 = M - m \qquad [8]$$

if d_4 = distance between reinforcement in flanges

additional steel in tension flange $= m^1 \div (d_4\, f_t)$ [9]

" " " compression flange $= m \div (15\, d_4\, u_c)$ [10]

DESIGN OF T BEAMS.

By the use of the "Table for Designing T Beams," T beams may be designed in exactly the same manner as simple rectangular beams, by considering the width "b_2" of the T beam to correspond to the width "b_1"

of the rectangular beam, and the area of concrete above the steel to be equal to "d_2b_2"

When the thickness "t" of the flange is less than the distance from the compressive surface of the slab to the neutral axis, the unit stresses on concrete in compression are increased, and therefore in designing T beams as if they were simple rectangular beams, a corresponding reduction in the allowable unit stresses on concrete in compression, and a corresponding reduction in the percentage of reinforcement must be made.

The following table gives this reduction in allowable stresses on concrete in terms of the ratio of the thickness of the flange "t" to the depth "d_2" and the ratio of the width "b_2" of the T beam to the width "b_1" of the stem.

The corresponding allowable percentage of steel reinforcement may be obtained from the "Table of Constants and Concrete Unit Stresses for Different Percentages of Steel."

In the investigation of T beams, the actual compressive stress may be obtained by computing the compressive stress which would occur in a simple beam of width "b_2" and multiplying this by the ratio of 750 divided by the unit stress given in the Table for Designing T Beams for the given value of "$\frac{t}{d_2}$" and "$\frac{b_2}{b_1}$"

TABLE FOR DESIGNING T BEAMS

FOR HIGH STEEL. $f_t = 20000$										
$t \div d_2$	$b_2 \div b_1$									
	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
.10	669	629	603	586	574	564	557	551	546	543
.15	700	674	660	650	642	636	632	629	627	625
.20	723	709	700	694	690	687	685	683	682	681
.25	737	732	728	725	723	722	721	720	719	718
.30	745	743	742	742	741	741	741	741	741	741
.35	750	750	750	750	749	749	749	749	748	748

FOR MEDIUM STEEL. $f_t = 16000$										
$t \div d_2$	$b_2 \div b_1$									
	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
.10	660	611	584	565	550	538	529	523	518	514
.15	690	657	639	625	617	610	604	600	597	595
.20	712	692	681	673	668	664	661	659	657	655
.25	728	718	712	708	705	702	700	698	697	696
.30	740	735	732	730	728	727	726	725	724	723
.35	746	745	744	744	743	743	743	742	742	742

VALUES OF μ_c TO BE USED IN DESIGNING T BEAMS AS SIMPLE RECTANGULAR BEAMS ARE GIVEN IN BODY OF TABLE.

TABLE OF CONSTANTS AND CONCRETE UNIT STRESSES FOR VARIOUS PERCENTAGES OF STEEL

PERCENTAGE OF REINFORCEMENT	$\frac{E_s}{E_c}$	WORKING STRENGTH OF STEEL	WORKING STRENGTH OF CONCRETE	A	x	C
0.20	15	20000	370	.928	.217	9.93
0.30	15	20000	463	.914	.258	848
0.40	15	20000	550	.903	.292	7.58
0.45	15	20000	588	.898	.306	7.28
0.50	15	20000	627	.893	.320	7.00
0.55	15	20000	663	.889	.332	6.78
0.60	15	20000	699	.885	.344	6.57
0.65	15	20000	734	.882	.355	6.39
0.676	15	20000	750	.880	.360	6.31
0.676	15	20000	633 by parabolic theory.			
0.40	15	16000	440	.903	.292	7.59
0.50	15	16000	500	.893	.320	7.00
0.60	15	16000	558	.885	.344	6.57
0.65	15	16000	587	.882	.355	6.39
0.70	15	16000	613	.878	.365	6.24
0.75	15	16000	640	.875	.375	6.10
0.80	15	16000	666	.872	.384	5.97
0.87	15	16000	702	.868	.397	5.80
0.90	15	16000	717	.866	.402	5.75
0.95	15	16000	741	.863	.410	5.65
0.97	15	16000	750	.862	.413	5.62
0.97	15	16000	629 by parabolic theory.			

Unit stresses in concrete 15% less when computed by "Parabolic" instead of "Straight Line" theory.

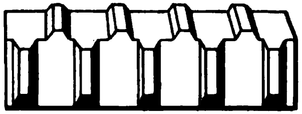
PROPERTIES OF PLAIN SQUARE AND ROUND BARS

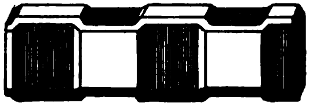
SQUARE BARS			ROUND BARS			
SIDE IN INCHES	WEIGHT PER FOOT	SECTIONAL AREA	DIAMETER IN INCHES	WEIGHT PER FOOT	SECTIONAL AREA	CIRCUM-FERENCE
$\frac{1}{4}$	.212	.0625	$\frac{1}{4}$	.167	.0491	.7854
$\frac{3}{8}$	.478	.1406	$\frac{3}{8}$	.375	.1104	1.1781
$\frac{1}{2}$	.850	.2500	$\frac{1}{2}$	.667	.1963	1.5708
$\frac{5}{8}$	1.328	.3906	$\frac{5}{8}$	1.043	.3068	1.9635
$\frac{3}{4}$	1.913	.5625	$\frac{3}{4}$	1.502	.4418	2.3562
$\frac{7}{8}$	2.603	.7656	$\frac{7}{8}$	2.044	.6013	2.7489
1	3.400	1.0000	1	2.670	.7854	3.1416
$1\frac{1}{8}$	4.303	1.2656	$1\frac{1}{8}$	3.379	.9940	3.5343
$1\frac{1}{4}$	5.312	1.5625	$1\frac{1}{4}$	4.173	1.2272	3.9270
$1\frac{3}{8}$	6.428	1.8906	$1\frac{3}{8}$	5.049	1.4849	4.3197
$1\frac{1}{2}$	7.650	2.2500	$1\frac{1}{2}$	6.008	1.7671	4.7124

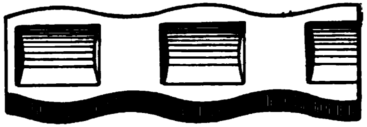
PROPERTIES OF PLAIN FLAT BARS

THICKNESS	WIDTH= $\frac{3}{4}''$		WIDTH= $1''$		WIDTH= $1\frac{1}{4}''$		WIDTH $1\frac{1}{2}''$	
	WEIGHT PER FOOT	AREA OF SECTION	WEIGHT PER FOOT	AREA OF SECTION	WEIGHT PER FOOT	AREA OF SECTION	WEIGHT PER FOOT	AREA OF SECTION
$\frac{1}{4}''$	.64	.1875	.85	.250	1.06	.313	1.28	.375
$\frac{5}{16}''$	.80	.2345	1.06	.313	1.33	.391	1.59	.469
$\frac{3}{8}''$	.96	.2815	1.28	.375	1.59	.469	1.92	.563
$\frac{7}{16}''$	1.11	.3280	1.49	.438	1.86	.547	2.23	.656
$\frac{1}{2}''$	1.28	.3750	1.70	.500	2.12	.625	2.55	.750

PROPERTIES OF CORRUGATED BARS







OLD STYLE BARS		
SIZE	WEIGHT PER FT.	NET SECTIONAL AREA
1/2"	0.64	0.18
3/4"	1.35	0.37
7/8"	1.95	0.55
1"	2.70	0.70
1 1/4"	4.00	1.07

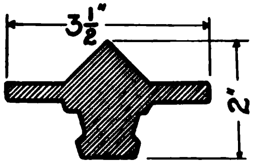
A VARIATION IN WEIGHT OF FIVE PER CENT IN EITHER DIRECTION IS REQUIRED ON ALL STYLES OF CORRUGATED BARS.

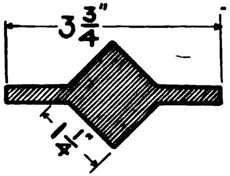
NEW STYLE BARS		
SIZE	WEIGHT PER FT.	NET SECTIONAL AREA
1/4"	0.24	0.06
1/3"	0.38	0.11
3/8"	0.48	0.14
1/2"	0.85	0.25
5/8"	1.33	0.39
3/4"	1.91	0.56
7/8"	2.60	0.77
1"	3.40	1.00
1 1/4"	5.31	1.56

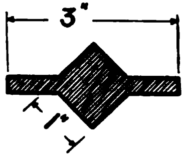
UNIVERSAL TYPE BARS		
SIZE	WEIGHT PER FT.	NET SECTIONAL AREA
1/4" x 1"	0.73	0.19
5/16" x 1 1/4"	1.18	0.32
3/8" x 1 3/8"	1.35	0.41
3/8" x 1 3/4"	1.97	0.54
3/8" x 2"	2.27	0.65
3/8" x 2 1/2"	2.85	0.80

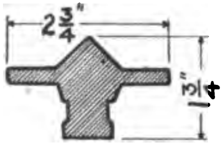
LARGER SECTIONS CAN BE ROLLED IF DESIRED

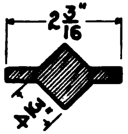
PROPERTIES OF KAHN BARS

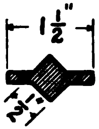








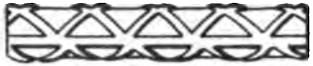




SIZE	WEIGHT PER FT.	AREA OF UNSHEARED BAR GROSS	AREA OF SHEARED BAR NET	AREA OF ONE DIAGONAL	LENGTH OF DIAGONALS	
					STANDARD	SPECIAL
$\frac{1}{2}'' \times 1\frac{1}{2}''$	1.4	0.41	0.25	0.08	6"	
$\frac{3}{4}'' \times 2\frac{3}{16}''$	2.7	0.79	0.56	0.115	12"	8"
1" × 3"	4.8	1.41	1.00	0.205	24"	18"
$1\frac{1}{4}'' \times 3\frac{3}{4}''$	6.8	2.00	1.60	0.20	24"	18" OR 30"
$1\frac{3}{4}'' \times 2\frac{3}{4}''$	6.8	2.00	1.60	0.20	24"	18" OR 30"
$2'' \times 3\frac{1}{2}''$	10.2	3.00	2.40	0.30	24"	30"

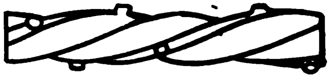
NOTE: 6", 8", AND 12" DIAGONALS ARE SHEARED OPPOSITE; 18", 24", AND 30" ARE SHEARED ALTERNATING.

PROPERTIES OF DIAMOND BARS



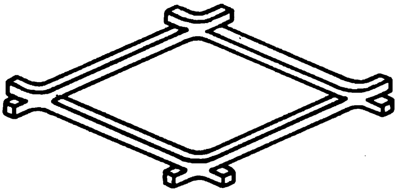
SIZE	WEIGHT PER FOOT	SECTIONAL AREA
1/4"	.213	.0625
3/8"	.478	.1406
1/2"	.850	.2500
5/8"	1.328	.3906
3/4"	1.913	.5625
7/8"	2.603	.7656
1"	3.400	1.0000
1 1/4"	5.312	1.5625

PROPERTIES OF. COLD TWISTED LUG BARS



SIZE	WEIGHT PER FOOT	SECTIONAL AREA
1/4"	.222	.0625
3/8"	.492	.1406
1/2"	.870	.2500
5/8"	1.350	.3906
3/4"	1.940	.5625
7/8"	2.640	.7656
1"	3.450	1.0000
1 1/8"	4.350	1.2656
1 1/4"	5.370	1.5625
1 1/2"	7.700	2.2500

PROPERTIES OF EXPANDED METAL



DESIGNATION			SECTION IN SQ. INCHES PER FT. OF WIDTH	WEIGHT PER SQUARE FOOT IN POUNDS.	SIZE OF STANDARD SHEETS	NUMBER OF SHEETS IN A BUNDLE	NUMBER OF SQ. FT. IN BUNDLE OF 8' 0" LENGTH
MESH	GAUGE (STUBS)	STRAND STANDARD OR EXTRA					
1/2"	Nº 18	Standard	.209	.74	3' or 6' x 8'	5	120
3/4"	" 13	"	.225	.80	6' x 8' or 12'	5	240
1 1/2"	" 12	"	.207	.70	4' x 8' or 12'	5	160
2"	" 12	"	.166	.56	5' x 8' or 12'	5	200
3"	" 16	"	.083	.28	6' x 8' or 12'	10	480
3"	" 10	Light	.148	.50	6' x 8' or 12'	5	240
3"	" 10	Standard	.178	.60	6' x 8' or 12'	5	240
3"	" 10	Heavy	.267	.90	4' x 8' or 12'	5	160
3"	" 10	Ex.Heavy	.356	1.20	6' x 8' or 12'	3	144
3"	" 6	Standard	.400	1.38	5' x 8' or 12'	3	120
3"	" 6	Heavy	.600	2.07	5' x 8' or 12	3	120
4"	" 16	Old Style	.093	.42	4 1/2' x 8' or 9'	6	216
6"	" 4	Standard	.245	.84	5' x 8' or 12'	5	200
6"	" 4	Heavy	.368	1.26	5' x 8' or 12'	3	120

APPENDIX C.

BRIEF PAVEMENT SPECIFICATIONS.

Concrete Pavement, when laid directly on top of reinforced concrete floor plates, will consist of a wearing surface two inches thick composed of cement mortar, one part Portland cement to three parts hard sand, crushed granite, or trap rock.

This wearing coat must be laid before the main floor slab has set, leveled to grade, troweled with a wooden float and marked off into blocks about six inches square by grooves one quarter inch deep. The two inches wearing surface must not be considered as part of the main floor slab.

When a concrete pavement is used there must be imbedded in the floor slab immediately below the two inch wearing coat, heavy expanded metal or woven wire mesh to prevent the wearing of the concrete below this plane.

Concrete pavements will not be used on bridges carrying very heavy city traffic but are recommended for country bridges and city bridges subjected to light traffic.

Concrete Curbs will preferably have metal reinforcement at the corner such as provided by the Wainwright curb, patented, or equally efficient protection.

They must be true to line and grade.

Concrete Pavement on Fills must be provided with a base composed of Mix No. 9 Portland concrete or Mix No. 9 Pozzulan concrete, four inches thick laid on a sand cushion and having heavy expanded metal imbedded about one inch above the lower surface.

On this base before same has set shall be laid the two inch wearing surface described above.

Wooden Block Pavement when used shall be composed of four inch creosoted timber blocks manufactured of heart yellow pine or blocks of equal quality.

On grades of three per cent or more, grooved blocks shall be laid. All work shall be done by Contractors or workmen experienced in laying this particular class of pavement.

The Contractor will be required to **Guarantee** the pavement for a period of ten years and keep same in repair for that length of time, and shall furnish bond securing the execution of said guarantee before final payment is made.

Pavement will be measured by the square yard in place.

When wood block pavement is laid on earth fill, there shall be prepared a subgrade as specified above under concrete pavements, except that there shall be laid one half inch of cement mortar 1 to 3 on top of the concrete, carefully leveled to grade and a 1 inch sand cushion shall be laid on top of the subgrade in all cases.

Brick Pavements will be composed of repressed vitrified paving bricks of best quality, sound, hard burned, uniform in size and color and not less than 3 inches by 8-1/2 inches in size.

All paving bricks must stand the following tests:

(a) When immersed in water for four days they shall not crack nor spall.

(b) The Standard Rattler Test of the National Brick Makers Association.

(c) When dried for twenty-four hours at a temperature of not less than 212° Fahr. and then immediately immersed in water for twenty-four hours, no brick shall absorb more than three per cent of its weight.

(d) No paving brick shall crush under a load of 10,000 lbs. per square inch when tested on edge. After bricks are laid, they shall be rolled with a roller weighing not less than five tons.

The entire surface shall then be inspected, and all broken or chipped or irregular brick shall be removed and all irregularities in the grade corrected.

The entire surface shall be wet and the joints filled with Portland cement mortar, one part Portland cement and one part fine sand. Brick pavement shall be laid on a one inch sand cushion and when laid on earth fills shall have a four inch subgrade prepared as specified for wood block pavement. Bricks will also be subject to inspection before laying. When T rails are laid in brick pavements, special shaped bricks must be used against the rails. The Contractor must file with his bid sample bricks, showing the kind of brick to be used.

Asphalt Pavements when laid directly upon reinforced concrete floor plates shall be two and one-half inches in thickness including the binder course.

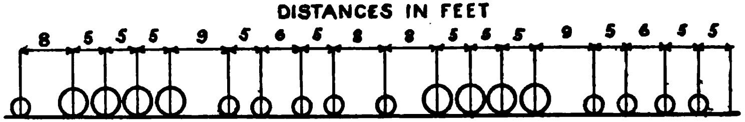
The pavement shall be equal in every respect to the best grade of standard asphalt pavement and the work shall be done by an established paving company making a specialty of laying this type of pavement. The Contractor shall **Guarantee** the pavement for ten years and keep it in repair during that time and shall furnish the Owner with the bond of an approved surety company securing the execution of the guarantee.

If asphalt pavement be laid on earth fill, it shall be provided with a four inch subgrade as provided for concrete pavements. Asphalt shall not be laid against rails, and special brick or stone block paving must be provided against all railway rails.

Sidewalks on approaches and fills shall have a total depth of ten inches, composed of six inches of cinders or sand thoroughly compacted on which shall be laid three inches of Portland concrete Mix No. 9 and on top of this and before it has set, shall be laid the top coat one inch thick composed of Portland cement one part to two parts graded hard sand or crushed granite or trap or equally hard stone. The surface shall be screeded and floated with a wooden dotted or grooved float and divided into blocks about four feet square.

APPENDIX D

COOPER'S STANDARD LOADING

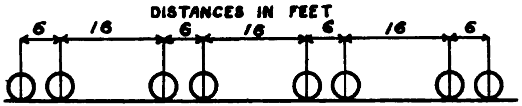


Class																			Uniform Load
E60	30000	60000	60000	60000	60000	39000	39000	39000	39000	30000	60000	60000	60000	60000	39000	39000	39000	39000	6000 lbs. per lin. ft.
E40	20000	40000	40000	40000	40000	26000	26000	26000	26000	20000	40000	40000	40000	40000	26000	26000	26000	26000	4000 lbs. per lin. ft.

Loads given are axle loads.

APPENDIX D

STANDARD LOADING FOR ELECTRIC RAILWAY BRIDGES



Class								
100 Ton Cars	50000	50000	60000	50000	50000	50000	60000	50000
50 Ton Cars	25000	25000	25000	25000	25000	25000	25000	25000

Loads given are axle loads.

APPENDIX E

COEFFICIENTS OF IMPACT

L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$
5	0.984	31	0.906	57	0.840	83	0.783	145	0.674
6	0.980	32	0.904	58	0.838	84	0.781	150	0.667
7	0.977	33	0.901	59	0.836	85	0.779	155	0.659
8	0.974	34	0.898	60	0.833	86	0.777	160	0.652
9	0.971	35	0.896	61	0.831	87	0.775	165	0.645
10	0.968	36	0.893	62	0.829	88	0.773	170	0.638
11	0.965	37	0.890	63	0.826	89	0.771	175	0.632
12	0.962	38	0.888	64	0.824	90	0.769	180	0.625
13	0.958	39	0.885	65	0.822	91	0.767	185	0.619
14	0.955	40	0.882	66	0.820	92	0.765	190	0.612
15	0.952	41	0.880	67	0.817	93	0.763	195	0.606
16	0.949	42	0.877	68	0.815	94	0.761	200	0.600
17	0.946	43	0.875	69	0.813	95	0.759	210	0.588
18	0.943	44	0.872	70	0.811	96	0.758	220	0.577
19	0.940	45	0.870	71	0.809	97	0.756	230	0.566
20	0.937	46	0.867	72	0.806	98	0.754	240	0.556
21	0.935	47	0.865	73	0.804	99	0.752	250	0.546
22	0.932	48	0.862	74	0.802	100	0.750	260	0.536
23	0.929	49	0.860	75	0.800	105	0.741	270	0.526
24	0.926	50	0.857	76	0.798	110	0.732	280	0.517
25	0.923	51	0.855	77	0.796	115	0.725	290	0.508
26	0.920	52	0.852	78	0.794	120	0.714	300	0.500
27	0.917	53	0.850	79	0.792	125	0.706	400	0.429
28	0.915	54	0.847	80	0.789	130	0.698	500	0.375
29	0.912	55	0.845	81	0.787	135	0.690	600	0.333
30	0.909	56	0.843	82	0.785	140	0.682		

APPENDIX F

WORKING UNIT STRESSES FOR TIMBER

Group	Quality	Transverse Loads			End Bearing			Columns, Length ≤ 12 × Side			Bearing Across Fibre			Shear Across Fibre			Shear Along Fibre			Working Modulus of Elasticity
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	
No.1 Long Leaf Yellow Pine Cuban Pine	No.1	2000	1600	1200	1650	1350	1000	1150	950	700	500	400	300	2000	1600	1200	250	200	150	750000
	No.2	1350	1050	800	1100	900	650	750	600	450	350	250	200	1350	1050	800	200	150	100	
No.2 White Oak Post Oak	No.1	1850	1450	1100	1650	1350	1000	1150	950	700	750	600	450	1650	1350	1000	350	275	200	600000
	No.2	1250	1000	750	1100	900	650	750	600	450	500	400	300	1100	900	650	250	200	150	
No.3 Short Leaf Pine Red and Black Oaks	No.1	1650	1350	1000	1350	1050	800	1000	800	600	350	250	200	1850	1450	1100	250	200	150	600000
	No.2	1100	900	650	900	700	550	650	550	400	250	200	150	1250	1000	750	200	150	100	
No.4 White Pine Norway (Red) Pine Poplar Bald Cypress Douglas (Oregon) Fir Western Hemlock (Washington Pine)	No.1	1350	1050	800	1100	900	675	850	650	500	250	200	150	1000	800	600	175	150	100	500000
	No.2	900	700	550	750	600	450	600	450	350	200	150	100	650	550	400	110	90	70	
No.5 Eastern Hemlock Chestnut Tamarack	No.1	1150	950	700	1100	850	650	850	650	500	250	200	150	650	550	400	135	105	80	500000
	No.2	750	600	450	750	600	450	600	450	350	200	150	100	450	350	250	90	75	55	
Approx. Factor of Safety		4.8	6	8	4.8	6	8	4.8	6	8										

A = For Members free from Impact and Exposure to Weather and for Timber used in Temporary Construction.
B = " " subject to " or " " ".
C = " " " " " and " " ".
When Impact is included in total stress, make no allowance for it in unit stress.
Quality No 1 corresponds to No 1 common dimension standard yellow pine grading rules.
Quality No 2 " " " No 2 " " " " " " "
Quality No 2 includes all green timber.

APPENDIX G

RETAINING WALL EARTH PRESSURES

HEIGHT	$\theta=0°$; $\phi=45°$		$\theta=\phi=45°$		$\theta=0°$; $\phi=\tan^{-1}\frac{1}{1.5}$		$\theta=\phi=\tan^{-1}\frac{1}{1.5}$		$\theta=0°$; $\phi=\tan^{-1}\frac{1}{2}$		$\theta=\phi=\tan^{-1}\frac{1}{2}$	
	UNIT PRESS.	TOTAL PRESS.	UNIT PRESS.	TOTAL PRESS.	UNIT PRESS.	TOTAL PRESS.	UNIT PRESS.	TOTAL PRESS.	UNIT PRESS.	TOTAL PRESS.	UNIT PRESS.	TOTAL PRESS.
6	103	309	424	1273	172	516	499	1498	229	688	536	1610
8	137	549	566	2263	229	917	666	2663	306	1222	716	2862
10	172	858	707	3536	286	1432	832	4160	382	1910	894	4472
12	206	1235	849	5091	344	2062	998	5990	458	2750	1073	6440
14	240	1681	990	6930	401	2807	1165	8154	535	3743	1252	8765
16	275	2196	1131	9051	458	3666	1331	10650	611	4889	1431	11448
18	309	2799	1273	11455	516	4640	1498	13479	688	6188	1610	14490
20	343	3431	1414	14142	573	5728	1664	16641	764	7639	1789	17889
22	377	4152	1556	17112	630	6931	1831	20136	840	9244	1968	21645
24	412	4941	1697	20364	687	8249	1997	23963	917	11000	2147	25640
26	446	5779	1838	23900	745	9681	2163	28123	993	12910	2326	30232
28	480	6726	1980	27719	802	11228	2330	32616	1070	14973	2504	35062
30	515	7721	2121	31820	859	12889	2496	37442	1146	17189	2683	40249
32	549	8784	2263	36204	917	14665	2663	42601	1222	19557	2862	45795
34	583	9917	2404	40871	974	16555	2829	48092	1299	22078	3041	51698
36	618	11118	2546	45821	1031	18560	2995	53917	1375	24752	3220	57959
38	652	12387	2687	51053	1088	20680	3162	60074	1451	27578	3399	64578
40	686	13726	2828	56569	1146	22914	3328	66564	1528	30558	3578	71554

Note:-Values were computed from Rankine's formulae for earth pressure.
Direction of pressure is parallel to surface of earth. θ= angle of surcharge. ϕ= angle of repose.
Weight of earth assumed at 100 lbs. per cubic foot

APPENDIX H.

DATA REQUIRED FOR DESIGNING REINFORCED CONCRETE BRIDGES.

1. Class of bridge desired.
2. Width of roadway.
3. Number of Street Railway tracks and distance apart.
4. Width of sidewalks.
5. Paving desired.
6. Sidewalk finish desired.
7. Clear width of openings required.
8. Number of spans required.
9. Distance from average low water level (or in the case of bridges over railroads from top of rail, or in the case of bridges over highways from grade of lower highway) to grade.
10. Depth of water at average low water level.
11. Distance from average low water level to extreme high water mark.
12. Distance from average low water level to usual high water mark.
13. Distance from average low water level to grade of adjacent bridges, if any over same stream, and also clear span of such adjacent bridges.
14. Approximate area of land in square miles drained by stream.
15. Approximate grade of stream in feet per mile.
16. Does the stream carry floating logs, debris or ice when in flood.
17. Character of bed of stream, mud, gravel, shale, or rock.
18. Character of banks of stream, height above average water level, and approximate angle of slope.

19. Character of foundations for piers or abutments at average low water.

At five feet below low water.

At ten feet below low water.

At fifteen below low water.

At twenty feet below low water.

20. Angle of crossing.

21. Grade of roadway, ascending north, south, east or west.

22. Approximate cost of broken stone, gravel, slag, sand and cement delivered at the bridge site.

23. Nearest railroad siding.

24. Nature of present bridge and disposition thereof.

25. Traffic maintained or diverted during construction of new bridge.

26. Sketch profile and plan of crossing.

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CONSULTATION. ❧ EXPERT CRITICISM OF AND CHECKING OF PLANS. ❧ DESIGNING, INSPECTING, REPORTING UPON, AND SUPERINTENDING THE CONSTRUCTION OF, ALL KINDS OF BRIDGES, BUILDINGS, AND SPECIAL STRUCTURES

Author of General Specifications for Concrete Bridges. ❧ Author of General Specifications for Concrete Work as applied to Building Construction

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